DESIGN A HORIZONTAL CONSTRUCTION PROJECT

The purpose of this lesson is to provide you with the knowledge to design the horizontal and vertical alignments for a military road.

Terminal Learning Objective

- Provided a horizontal constructions mission, a scientific calculator, a survey set general purpose (GP), soil test set and references, design a horizontal construction project to meet construction mission requirements per acceptable construction standards and the references. (1361-SRVY-2005)

Enabling Learning Objectives

1. Given a horizontal constructions mission, site plans, and references, identify site reconnaissance features per the MCRP 3-17A. (1361-SRVY-2005b)
2. Given written site reconnaissance date, and references, calculate the estimated storm runoff volumes per the FM 5-430-00-1.

Enabling Learning Objectives

3. Given calculated storm runoff volumes, and references, determine culvert system requirements per the TM 5-820-4. (1361 SRVY-2005c)
4. Given calculated storm runoff volumes, and references, determine open ditch design requirements per the FM 5-430-00-1. (1361-SRVY-2005d)

Enabling Learning Objectives

5. Given a horizontal construction mission, vehicle usage requirements, and references, determine the road classification criteria per the FM 5-430-00-1. (1361-SRVY-2005e)
6. Given a horizontal construction mission, anticipated aircraft usage requirements, and references, determine landing zone criteria per the FM 5-430-00-2. (1361-SRVY-2005g)

Enabling Learning Objectives

7. Given a horizontal construction mission, site reconnaissance data, a computer, software applications, and references, design the horizontal project alignments per the Terramodel User Guide. (1361-SRVY-2005g)
8. Given a horizontal construction mission, site reconnaissance data, a computer, software applications, and references, design the vertical

Administrative Data

- Method/Media: Lecture, slide show, demonstration, practical application
- Safety: No major safety concerns
- Risk Assessment Level: Low
- Environmental Considerations: None
- Evaluation: Students must score a minimum of 80% on a Performance based Written Evaluation .

SITE RECONNAISSANCE

- **The site reconnaissance is conducted to determine if the proposed location for the road is feasible, or if an alternate route needs to be selected.**

- **This should be performed jointly with the Project Officer, Engineer Equipment Chief, and Combat Engineer Chief if possible.**

RECONNAISSANCE CONSIDERATIONS

- **Terrain restrictions.**
- **Location of existing roads.**
- **Location and utilization of existing bridges.**
- **Natural or manmade obstacles.**

RECONNAISSANCE CONSIDERATIONS

- Vegetation and undergrowth.
- Engineering effort involved for construction.
- Existing soil conditions.
- Location of possible borrow pit sites.

PRELIMINARY ROAD LOCATION FACTORS

- **Soil Characteristics: Locate roads on terrain having the best subgrade soil conditions to decrease construction efforts and ensure a better road.**

- **Drainage: Locate roads in areas that easily drain, and where the construction of drainage structures is minimized.**

- **Topography: Avoid excessive grades and steep hills. Locate roads on the side of a hill instead of going directly over it.**

PRELIMINARY ROAD LOCATION FACTORS

- **Earthwork: Earthwork operations is the single largest work item during the construction of a road. Balancing cut and fill volumes will decrease hauling distances, and the work required to handle the material.**

- **Alignments: Keep the number of curves and grades to a minimum. Avoid excessive grades which cause mobility problems.**

FINAL ROAD LOCATION

- **Locate portions of the new road along existing roads whenever possible.**
- **Locate the road on a stable soil that easily drains. Avoid low lying areas where water will cause surface and subsurface drainage problems.**
- **Avoid areas with high water tables. These areas will cause continuing problems caused by water damage.**

FINAL ROAD LOCATION

- **Locate roads along ridges and streamlines to keep the construction of drainage structures to a minimum. Keep the road well above the waterline to prevent flooding.**
- **Locate roads along contour lines to prevent unnecessary earthwork operations.**
- **Select locations that avoid rock work or excessive clearing and grubbing.**
- **Avoid sharp curves and routes which require bridging.**

RECORDING RECONNAISSANCE OBSERVATIONS

- **Make your notes as detailed as possible when performing the site reconnaissance.**
- **Use a rough checklist to help you with your site observations if need be.**
- **Make a rough sketch of the project area.**

QUESTIONS?

DRAINAGE HYDROLOGY CYCLE

The drainage hydrology cycle is the continuous process which carries water from the ocean to the atmosphere to the land, and back to sea.

A number of sub-cycles take place at the same time during the overall cycle.

PRECIPITATION

Rainfall is the primary area of concern when it comes to determining the type of drainage system to be constructed.

INTERCEPTION

Rainfall coming to rest on vegetation is intercepted.

Large quantities of water can be trapped in the canopy of trees and plants.

INFILTRATION

A significant portion of the water that actually strikes the soil soaks into the ground by infiltration.

Storm-water runoff begins to accumulate when the rate of rainfall exceeds the rate of infiltration.

DETENTION

Detention is the amount of water required to fill depressions of any size in the earth's surface.

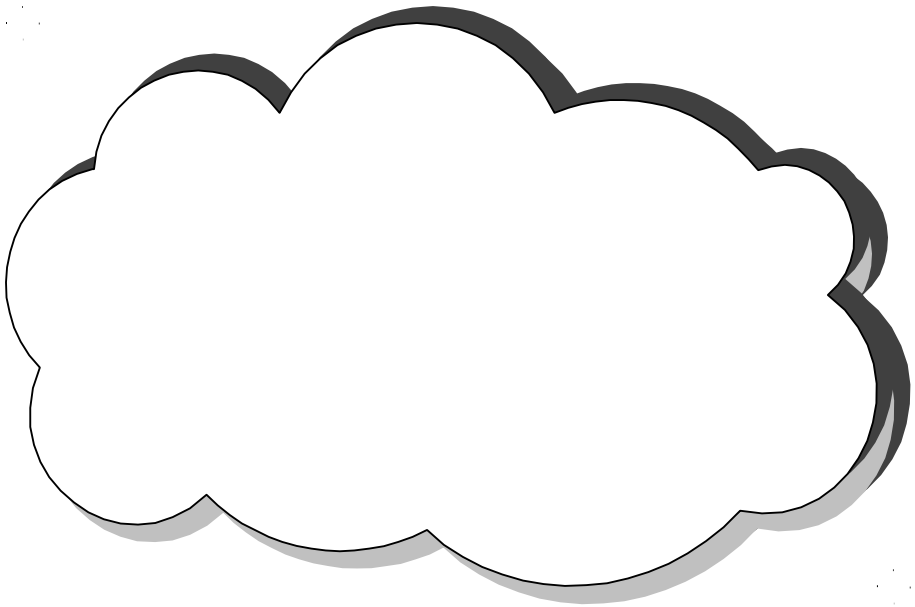
TRANSPIRATION

Vegetation returns water to the atmosphere through transpiration.

Because of the time involved during this process, it has no immediate effect on water runoff.

RUNOFF

Runoff is the volume of water that is left over after evaporation, interception, and detention moisture losses are removed.



STORMS

Storms can deliver a large quantity of water to the earth in a short period of time.

Storm runoff is determined by duration, frequency, and intensity.

QUESTIONS?

BREAK?

DRAINAGE

Inadequate drainage is the most common cause of road failure. Simple rules of thumb to follow are:

- **Develop drainage systems before, during, and after the construction of the road to ensure surface water is effectively carried away from the road surface and adjacent areas.**

- **Serviceability of the road depends on the adequacy of the drainage system.**

DRAINAGE

- **Estimated water runoff volumes are calculated to determine the proper drainage system to be constructed.**
- **To much water on the road will cause it to eventually fail.**
- **Surface ditching and culvert systems are used to effectively channel water away from the road surface and adjacent areas.**
- **Erosion control systems are included in hilly, or mountainous areas.**

QUESTIONS?

HASTY RUNOFF ESTIMATION

- **This estimation method is used when time does not permit a more exact determination, but will still enable you to determine adequate ditching and culvert systems.**

- **This method of runoff determination does not take into account the size, shape, and slope of the area, surface vegetation, soil conditions, or rainfall intensity.**

HASTY RUNOFF ESTIMATION MEASUREMENTS

- **Locate a straight section along the ditch or gully at, or immediately adjacent to the construction site to take your measurements.**
- **Make a rough cross section sketch of the ditch or gully you are taking measurements of.**
- **Measure, and record on your sketch, the inside bottom width (W1) of the existing channel.**

HASTY RUNOFF ESTIMATION MEASUREMENTS

- **Measure, and record on your sketch, the upper width (W2) at the high water mark.**
  - **The high water mark is characterized by water flowing at higher than normal velocity.**
  - **The high flow velocity tends to cause notable bank erosion and undercutting, and tends to retard the growth of vegetation on the banks.**
  - **The high water mark is identified at the point where bank erosion begins and vegetation growth ceases.**
- **Measure, and record on your sketch, the height (H) from the bottom of the channel to the high water mark.**

HASTY RUNOFF FORMULA

The following trapezoidal formula will enable you to calculate the approximate volume of water to be carried by an open ditch or culvert, from a maximum annual rain producing storm.

$$Ca = \frac{(W1 + W2) \times H}{2}$$

- **Ca = Channel area in square feet rounded to two decimal places.**
- **W1 = Width of channel bottom to the nearest whole or half foot.**
- **W2 = Width at high water mark to the nearest whole or half foot.**
- **H = Height from channel bottom to high water mark to the nearest whole or half foot.**

HASTY RUNOFF EXAMPLE

- **Channel area (Ca) computation example:**

$$Ca = \frac{(3' + 6') \times 4'}{2}$$

Ca = 18.00 square feet.

PRACTICAL EXERCISE

QUESTIONS?

BREAK?

CULVERTS

- **A culvert is an enclosed waterway used to pass water from one point to another.**
- **They are an expedient and economical way to correct or improve existing drainage problems, and to prevent drainage problems during and after construction of a military road.**

CULVERT USE

- **Pass water through an embankment.**
- **Continue natural streams through an intercepting structure.**
- **Provide cross drainage in a fill section of a road.**
- **Provide ditch relief.**
- **Continue side ditches at road intersections.**
- **There are two classifications of culvert systems.**

PERMANENT CULVERTS

These types of culverts are permanent in nature.

- **Corrugated metal pipe. (CMP)**
- **Concrete pipe. (CP)**
- **Vitrified clay pipe. (VC)**
- **Polyvinyl chloride pipe. (PVC)**

EXPEDIENT CULVERTS

These types of culverts are used in expedient construction when permanent culverts are not available.

- **Logs and lumber.**
- **Oil drums.**
- **Landing mat and sandbags.**

<u>Culvert Installation</u>: The installation of the culvert itself is relatively simple, regardless if it is placed in an existing channel or in a newly constructed channel.

The following guidelines will help you

CULVERT INSTALLATION (Fill and Cover Depth)

- **Fill Depth: The depth of fill must be equal to or greater than the depth of the cover, plus the diameter of the culvert.**

- **Cover Depth: For road culverts the cover depth must be equal to half the diameter of the culvert that is used, or 12" inches, whichever is greater.**

CULVERT INSTALLATION (Bedding)

Bedding: Bedding is placed in the bottom of the trench to cushion the bottom of the culvert from crushing forces.

- **The depth of the bedding material that is used is equal to 1/10th of the diameter of the culvert it is supporting.**

CULVERT INSTALLATION (Culvert Slope)

Installing culverts with the proper slope (grade) will ensure that water will drain through it freely, and become self cleaning.

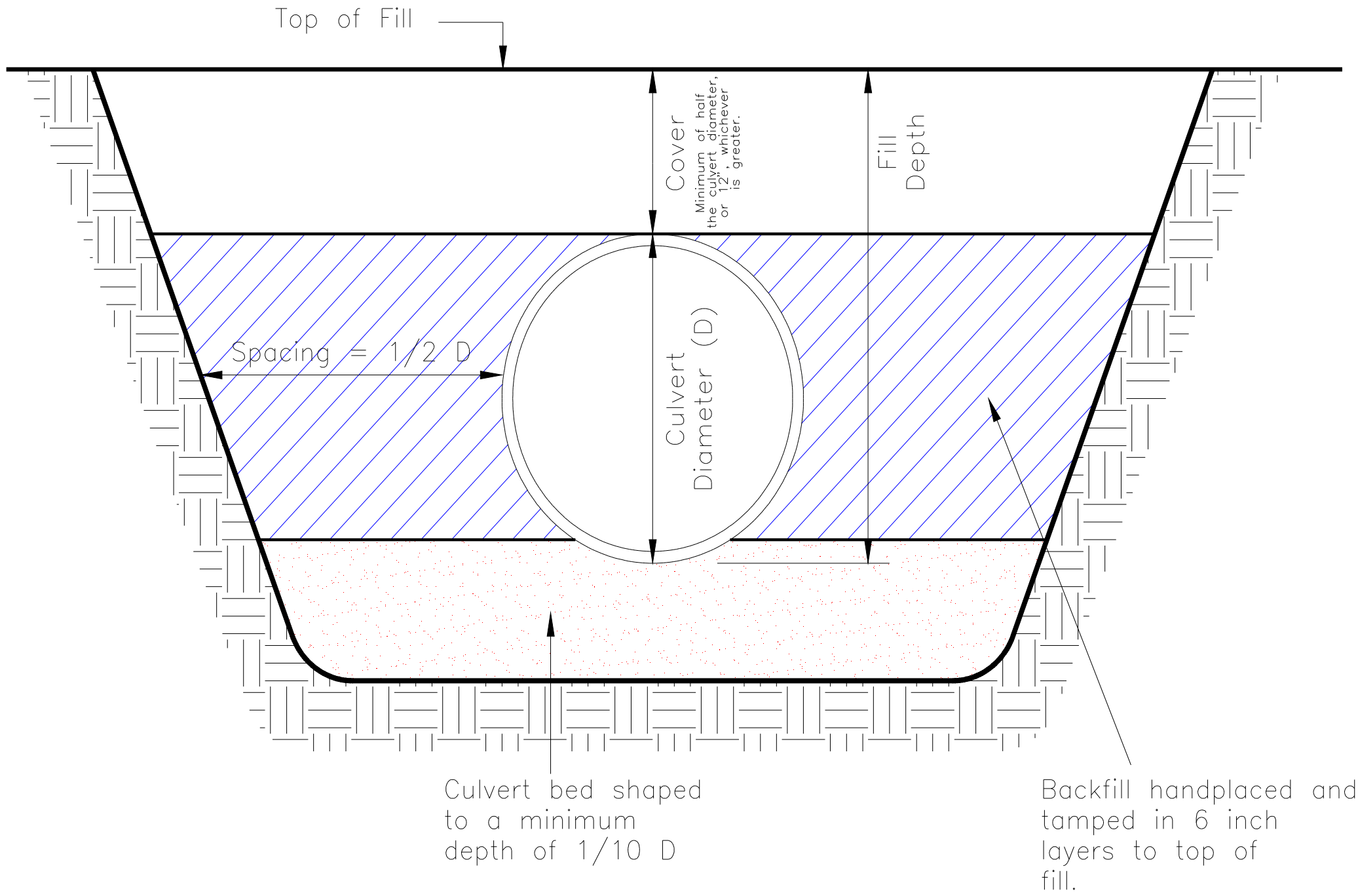
- **Install culverts in existing channels so the inlet and outlet inverts match the existing channel elevations.**

- **Slopes placed on culverts in newly constructed channels cannot be less than 0.50% in grade, or greater than 2.0% in grade.**

CULVERT INSTALLATION (Backfill)

Backfill: The backfill material will be hand placed and compacted so the placement of the culvert in the bedding is not disturbed.

- **The spacing distance between the sides of the culvert to the side of the trench is equal to 1/2 the diameter of the culvert that is used.**


Top of Fill
Cover
Minimum of half the culvert diameter, or 12", whichever is greater.
Fill Depth
Spacing = 1/2 D
Culvert Diameter (D)
Culvert bed shaped to a minimum depth of 1/10 D
Backfill handplaced and tamped in 6 inch layers to top of fill.

MAXIMUM DIAMETER (Dmax)

- **Permanent culverts are selected based on their diameter.**
- **The Maximum Diameter (Dmax) method is used to calculate the maximum diameter of culvert that can be used and still maintain the minimum amount of cover over it.**
- **The maximum diameter to be calculated is dependent upon the amount of fill used to bury the culvert.**

Dmax FOR FILLS 36“ or GREATER

- **Dmax = 2/3 x Fill**
  - ✓ **Dmax = Maximum culvert diameter in inches rounded to two decimal places.**
  - ✓ **2/3 = A constant that represents the minimum fill depth required for the maximum diameter of culvert.**
  - ✓ **Fill = Fill depth in inches rounded to two decimal places.**

Dmax FOR FILLS 36” or LESS

- **Dmax = Fill - 12"**
  - ✓ **Dmax = Maximum culvert diameter in inches rounded to two decimal places.**
  - ✓ **Fill = Fill depth in inches rounded to two decimal places.**
  - ✓ **12" = A constant that represents the minimum cover depth that is allowed to prevent crushing actions.**

QUESTIONS?

BREAK

Dmax EXAMPLE #1

- **You have a fill depth of 6 feet, with a compacted road depth of 1 foot. What is the Dmax?**
  - **Dmax = 2/3 x 7 feet**
  - **Dmax = 7' x 12" (fill depth converted to inches)**
  - **Dmax = 2/3 x 84" (84 x 243)**
  - **Dmax = 56.00 inches**

Dmax EXAMPLE #2

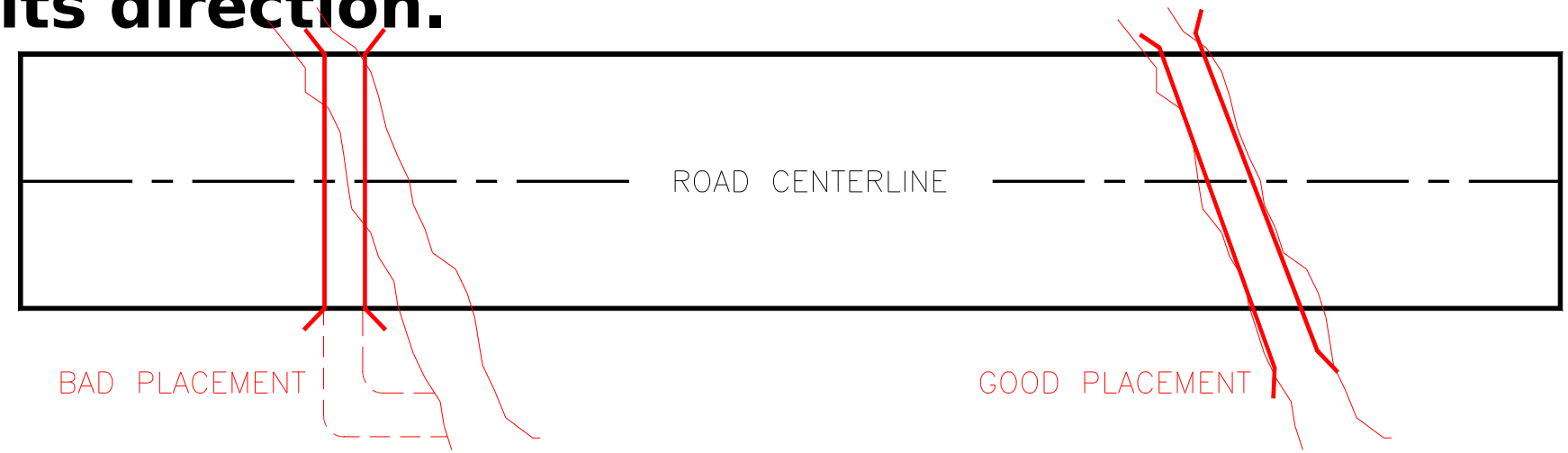
- **You have a fill depth of 2 feet 2 inches, with a compacted road depth of 7 inches. What is the Dmax?**
  - **Dmax = 33" - 12"**
  - **Dmax = 21.00 inches**

QUESTIONS?

BREAK

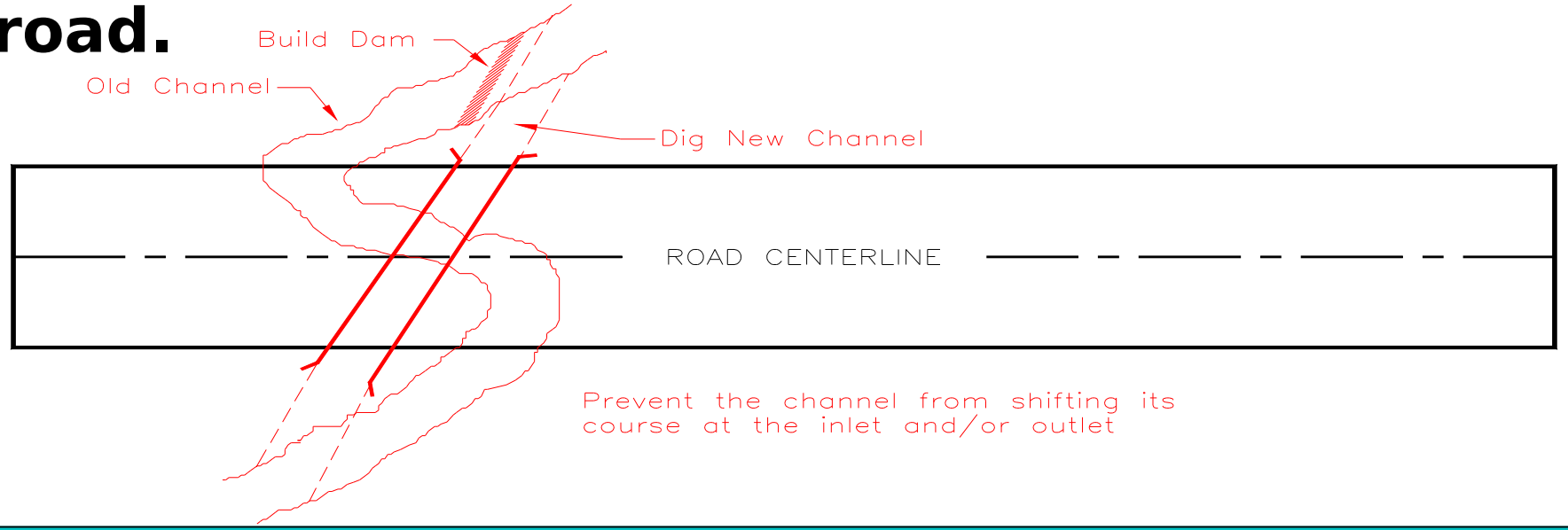
CULVERT ALIGNMENT

To maintain an existing drainage path, place the culvert directly in the channel bottom. If no change is made to the original path of the existing channel, the drainage will not change its direction.



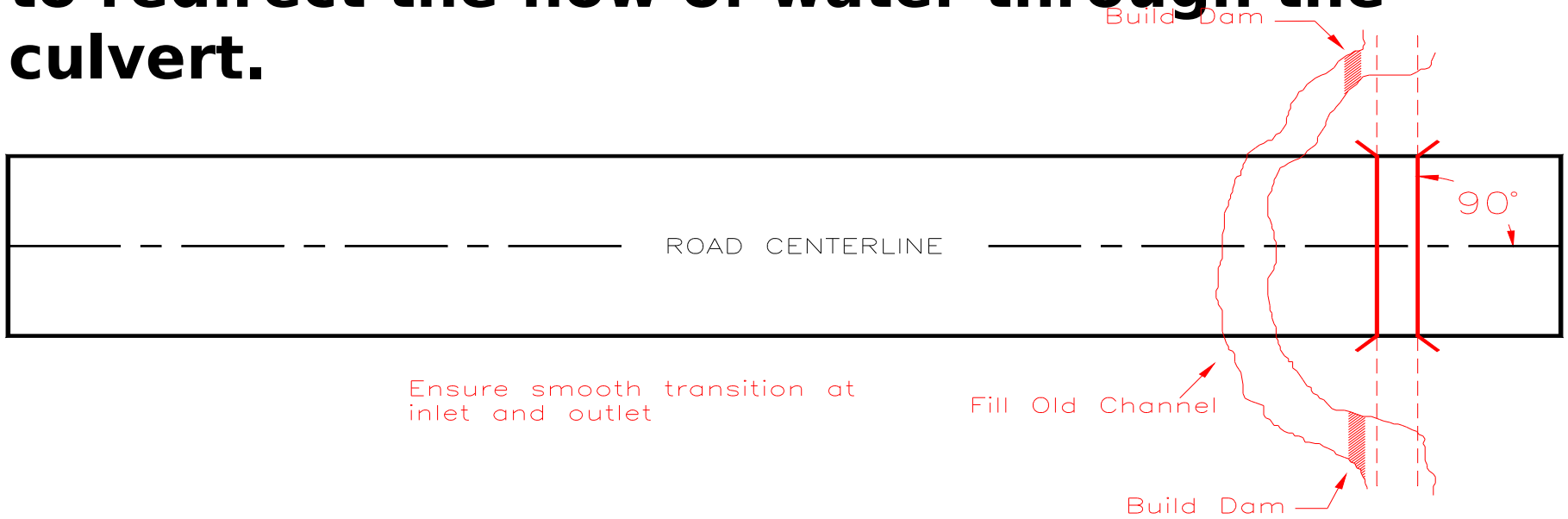
CULVERT ALIGNMENT

Sometimes the road must be constructed on a section where the channel meanders. In this case it is a good idea to cut a new path that will direct the existing channel away from the road.



CULVERT ALIGNMENT

The road may also cut across a bend in the channel. Place the culvert at a 90 degree angle to the road, and fill and compact the bend of the channel. Place a dam at the inlet and outlet to redirect the flow of water through the culvert.



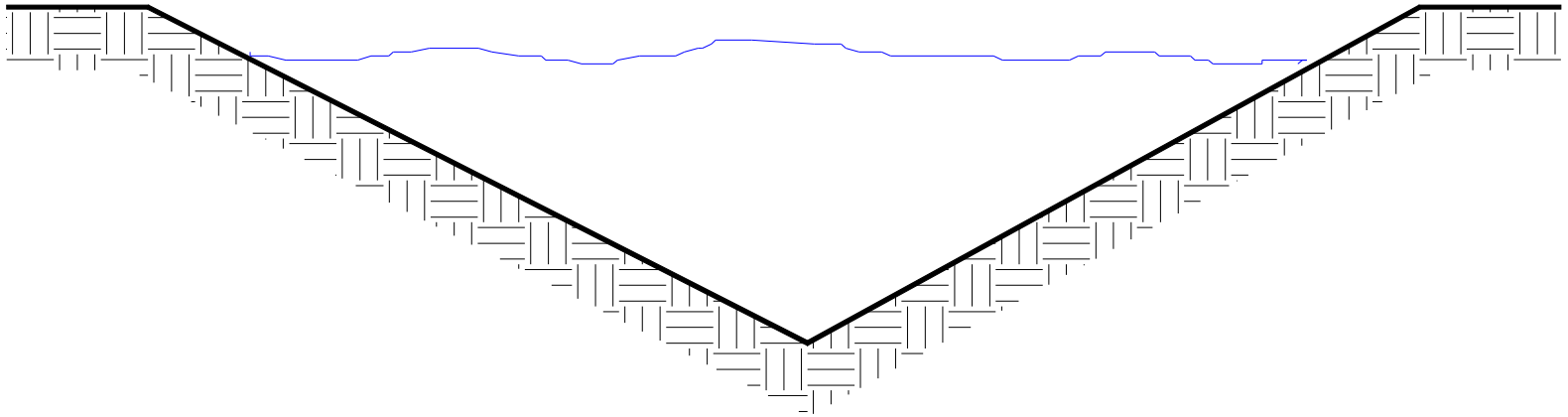
QUESTIONS?

OPEN DITCHES

- **Open ditches are located along the sides of a road to collect runoff from the road and adjacent areas and transport it to a culvert.**
  - **Triangular ditches are used to move <u>small quantities of water.</u>**
  - **Small quantities of water mean that the calculated channel area (Ca) is less than or equal to 15 square feet.**

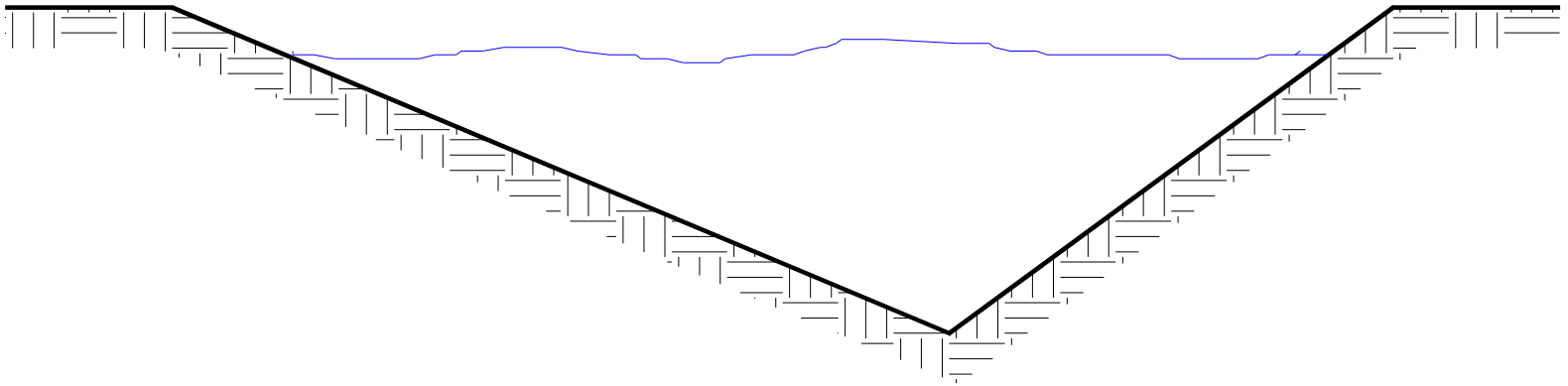
SYMMETRICAL TRIANGULAR DITCHES

- **Side slope ratios are equal.**



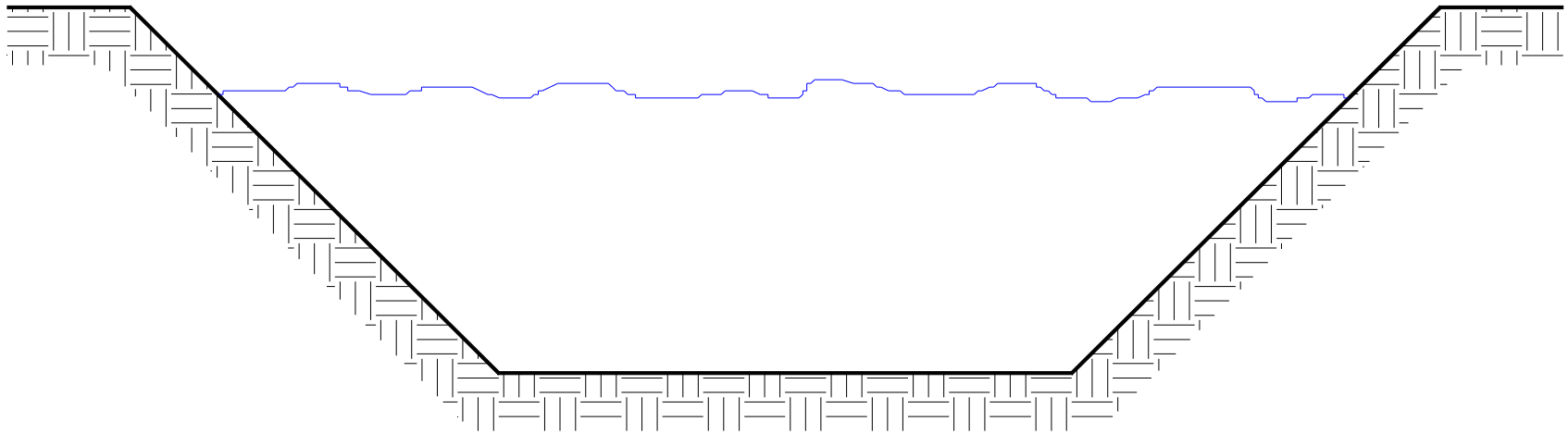
NON-SYMMETRICAL TRIANGULAR DITCHES

- **Side slope ratios differ in value.**



TRAPEZOIDAL DITCHES

- **Trapezoidal ditches are installed for large quantities of water when the calculated channel area (Ca) is greater than 15 square feet. The side slopes are symmetrical.**



DITCH SIDE-SLOPE RATIOS

Ditches have two sloped sides, with each having a respective slope ratio. This is expressed as horizontal feet to vertical feet.

- **If the side slopes are to steep, excessive erosion will occur, and the ditch will eventually clog with sediment.**
- **The ditch slope adjacent to the road shoulder is called the front slope.**
- **The opposite slope is called the back slope.**

DITCH SIDE-SLOPE RATIOS

The following rules of thumb applies to side-slope ratios for shallow ditches in relatively flat terrain:

- **Non-symmetrical "V" ditch slopes are cut at a 3:1 front slope, and a 1:1 back slope.**
- **Symmetrical ditch slopes for "V" or trapezoidal ditches are cut at either a 2:1 slope or a 3:1 slope.**

QUESTIONS?

BREAK

DITCH CALCULATIONS (Triangular Ditches)

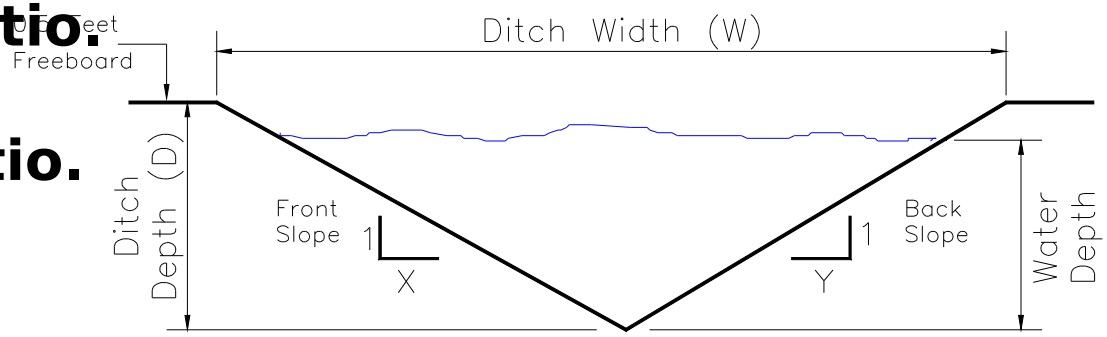
- **The depth and width of triangular ditches need to be calculated to ensure that the ditch will have sufficient holding capacity for the estimated runoff.**

  - **Ditch Depth:** $D = \sqrt{\frac{Ca \times 2}{X + Y}} + 0.5$

    - **D = Ditch depth in feet.**
    - **Ca = Channel are computed previously.**
    - **X =Horizontal run of the front slope ratio.**
    - **Y = Horizontal run of the back slope ratio.**
    - **0.5 = Safety factor constant. (1/2 foot freeboard)**

DITCH CALCULATIONS (Triangular Ditches)

- **Ditch Width: W = D x (X + Y)**
  - **W = Ditch width in feet. Rounded to the nearest whole foot.**
  - **D = Ditch depth in feet.**
  - **X = Front slope ratio.**
  - **Y = Back slope ratio.**



"V" DITCH CALCULATION (Example #1)

- **Given a calculated channel area (Ca) of 12 sqft., and a front slope of 3:1 and a back slope of 1:1.**

  - $D = \frac{12 \times 2}{3 + 1} + 0.5$

  - $D = \frac{24}{4} + 0.5$

  - $D = 6 + 0.5$

  - $D = 2.45' + 0.5$

  - **D = 2.95‘ round up to 3’**

W = 3' x (3 + 1)

W = 3' x 4

W = 12.00' feet

"V" DITCH CALCULATION (Example #2)

- **Given a calculated channel area (Ca) of 5 sqft., and a front slope of 2:1 and a back slope of 2:1.**

  - $D = \sqrt{\frac{5 \times 2}{2 + 2}} + 0.5$

  - $D = \sqrt{\frac{10}{4}} + 0.5$

  - $D = \sqrt{2.5} + 0.5$

  - D = 1.58' + 0.5

  - D = 2.08' round to 2’

  W = 2' x (2 + 2)

  W = 2' x 4

  W = 8.00' feet

QUESTIONS

PRACTICAL EXERCISES

QUESTIONS

DITCH CALCULATIONS (Trapezoidal Ditches)

- **The cross-sectional area of a trapezoidal ditch is computed as if it were a rectangle. The slope areas are not considered.**

- **The width of the bottom of the ditch is based on the width of the cutting edge of the equipment used to construct the ditch.**

  - **Ditch Depth:** $D = \frac{Ca}{W} + 0.5$
  - **D = Ditch Depth in feet. Rounded to nearest foot.**
  - **Ca = Channel area in square feet.**
  - **W = Width of ditch in feet.**
  - **0.5 = Safety factor constant. (1/2 foot of freeboard)**

TRAPEZOIDAL DITCH CALCULATION (Example)

- **Given a calculated channel area (Ca) of 18.8 sqft., a front ditch slope of 3:1, a back slope of 3:1, and a channel bottom width of 12 feet.**

- **$D = \frac{18.8}{12} + 0.5$**

- **D = 1.57' + 0.5**

- **D = 2‘ (rounded to the nearest whole foot)**

QUESTIONS

PRACTICAL EXERCISES

QUESTIONS

BREAK

EROSION CONTROL

- **The primary concern is to slow water velocity down in extremely hilly or mountainous areas.**
- **Water that runs too slowly will cause drainage systems to clog and ultimately fail.**
- **The desirable gradient for a ditch is between 0.5% to 2.0%.**
- **Ditches with a gradient of greater than 2.0% will require erosion control.**

EROSION CONTROL METHODS (Ditch Lining)

- **Ditches may be lined with various materials to prevent erosion:**
  - **The use of concrete, asphalt, rock and mortar will not decrease the velocity of the water, but it will protect the soil.**
  - **The use of grass will not only help to protect the soil, but it will also reduce the velocity. Grass seed is cheap, and is normally available for the construction site.**

EROSION CONTROL METHODS (Check Dams)

- **Check dams are nothing more than small wooden dams built from logs and timber to reduce the grade of the ditch.**
  - **The minimum spacing for check dams is at 50 foot intervals.**
  - **To reduce construction effort, the dams should be placed as far apart as possible, while achieving the desired grade.**
  - **Check dams should be checked periodically to allow free flow of water.**

QUESTIONS?

CONSTRUCTION SURVEYS

- **The purpose of construction surveys is to support the construction activities for the road.**
- **Construction surveys are broken down into three distinct phases.**

CONSTRUCTION SURVEY PHASES

- **Preliminary Survey**: **Control is set, a traverse of the proposed road route is established, and a topographical survey is conducted to create a site plan of the project area.**

- **Final Location Survey**: **The road centerline is set, cross sections and plan and profile drawings are created, and earthwork volume readouts are created.**

- **Construction Layout Survey**: **Grade stakes are set to establish the vertical alignment of subgrades and finish grade elevations, slope stakes are set at the limits of earth moving operations, and culvert locations are established.**

CONSTRUCTION SURVEY GUIDELINES

- Keep the **centerline** established at least **500 feet** ahead of clearing and stripping operations.
- Keep **rough grades** established and **slope stakes** set at least **250 feet** ahead of rough grade operations.
- Set **finish grades** at least **200 feet** ahead of finish grade operations.
- Ensure **traverse stations** along the road are **referenced** properly.

ALIGNMENT STAKES

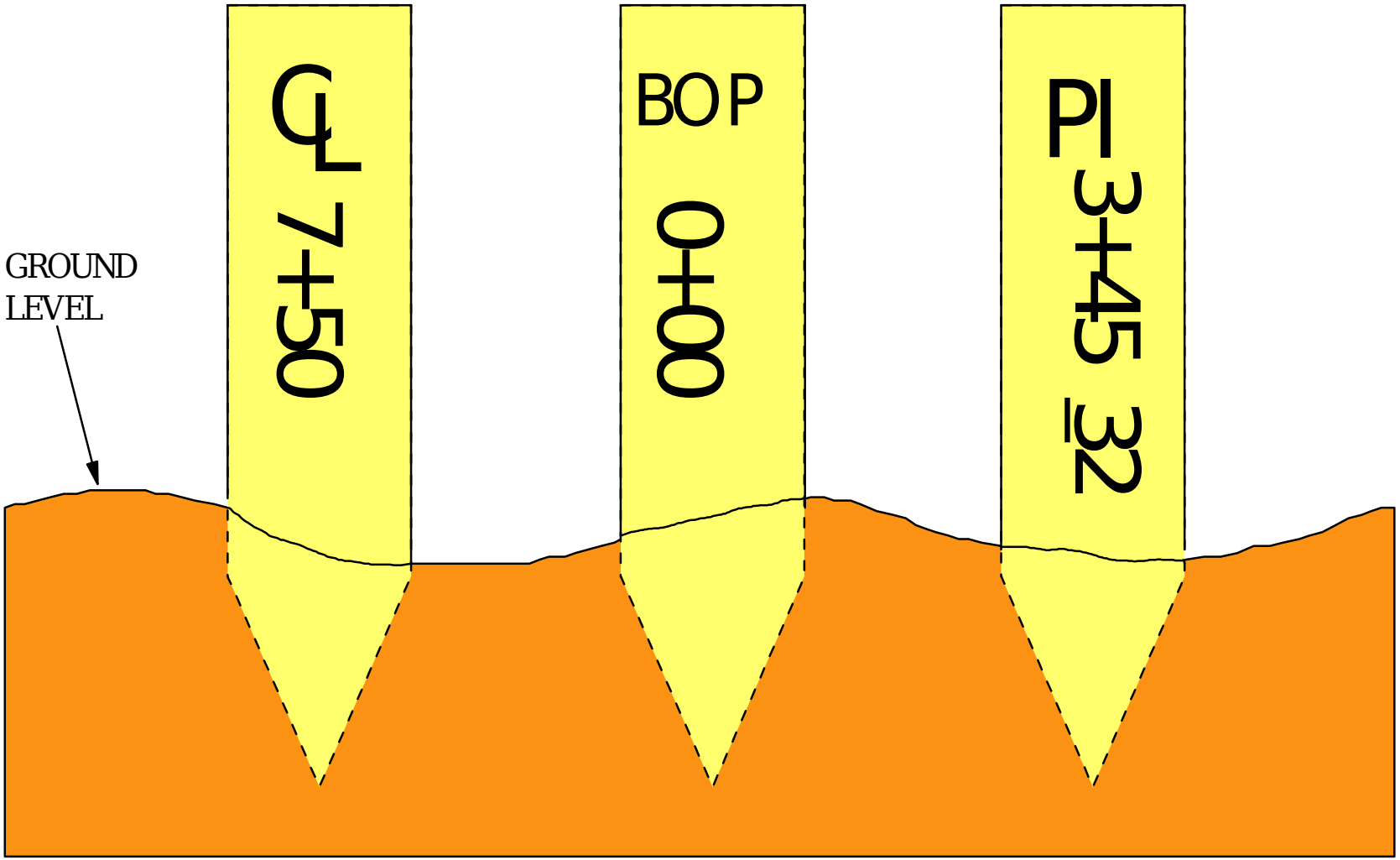
- **Alignment stakes indicate the horizontal alignment of the road and establish the subgrade and finish grade elevations, which guide equipment operators during earth moving operations.**

CENTERLINE STAKES (CL)

- **These stakes establish the location of the road centerline (CL).**
- **They are normally set at 100 foot station intervals starting at the beginning of the project (BOP), and proceeding to the end of project (EOP).**
- **They are marked with station values on the front of the stake which faces in the direction of the BOP.**

CENTERLINE STAKES

FACES BOP

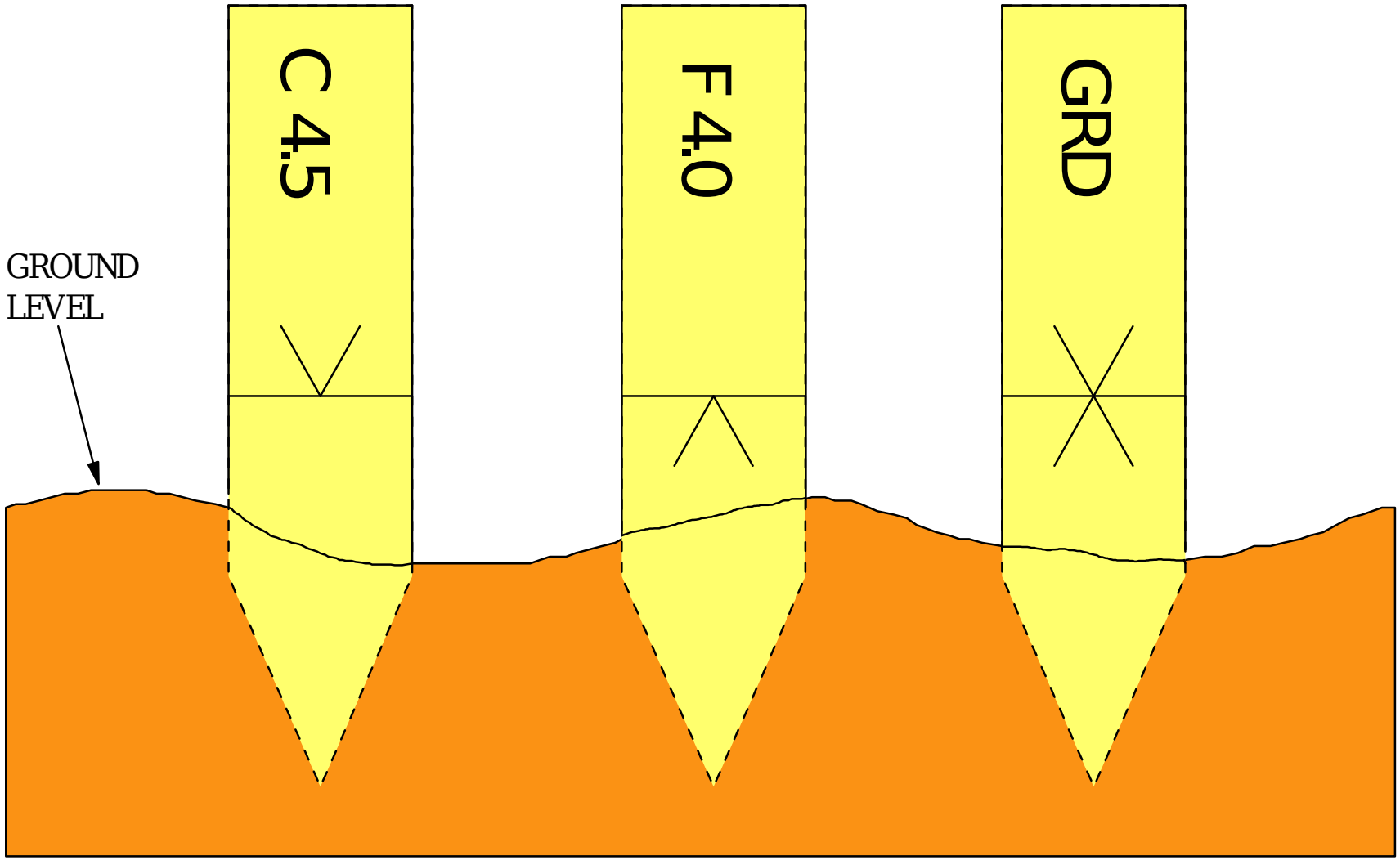


GRADE STAKES

- **These stakes guide grading operations during the establishment of the vertical alignment (subgrade and finish grade) for a road.**
- **They will indicate the amount of earth that must be cut or filled at each station along the road centerline.**
- **The back of the centerline stake will be marked with the cut or fill amounts, and will be shown to the nearest half of a foot.**

GRADE STAKES

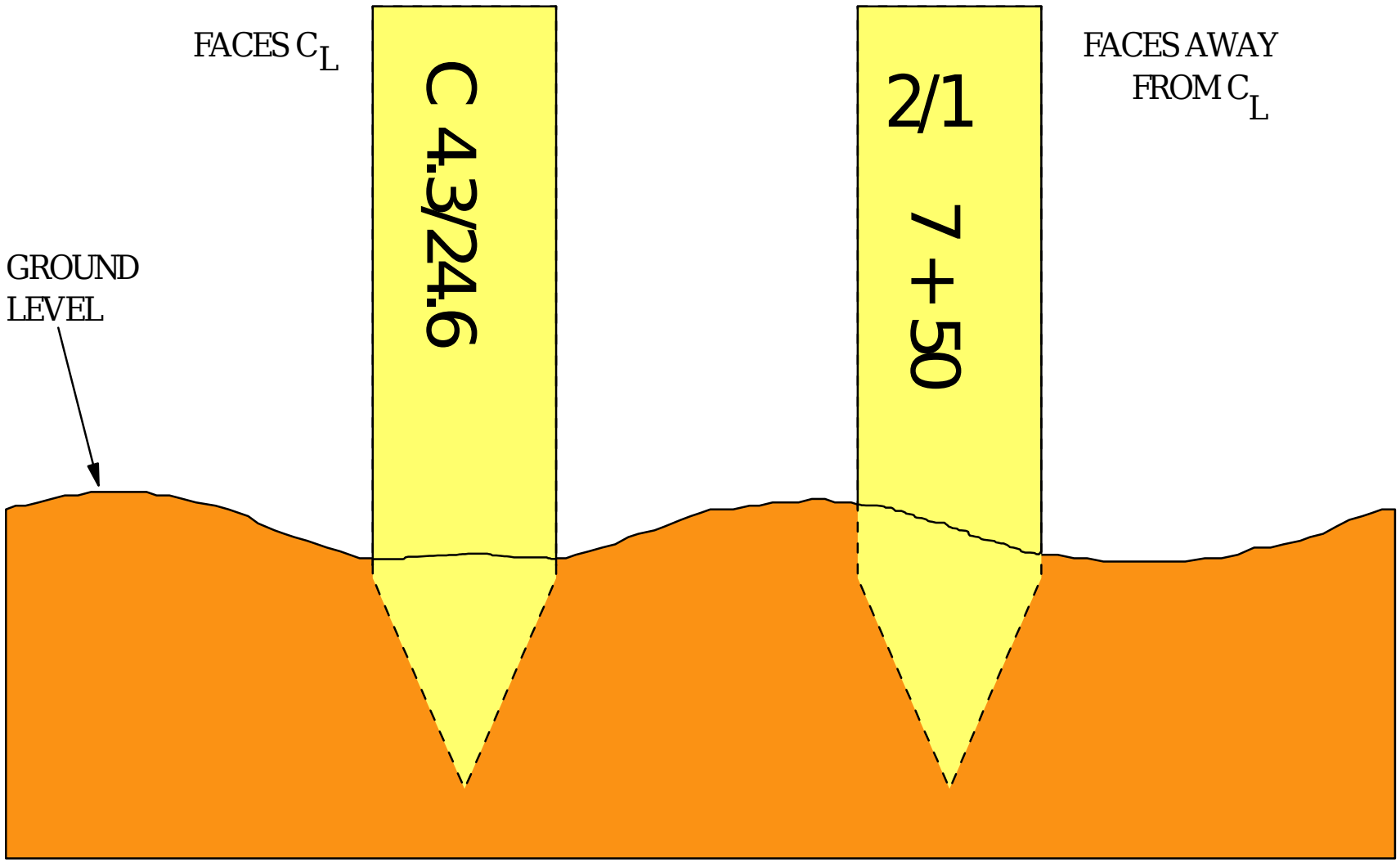
BACK OF CENTERLINE STAKE FACING EOP



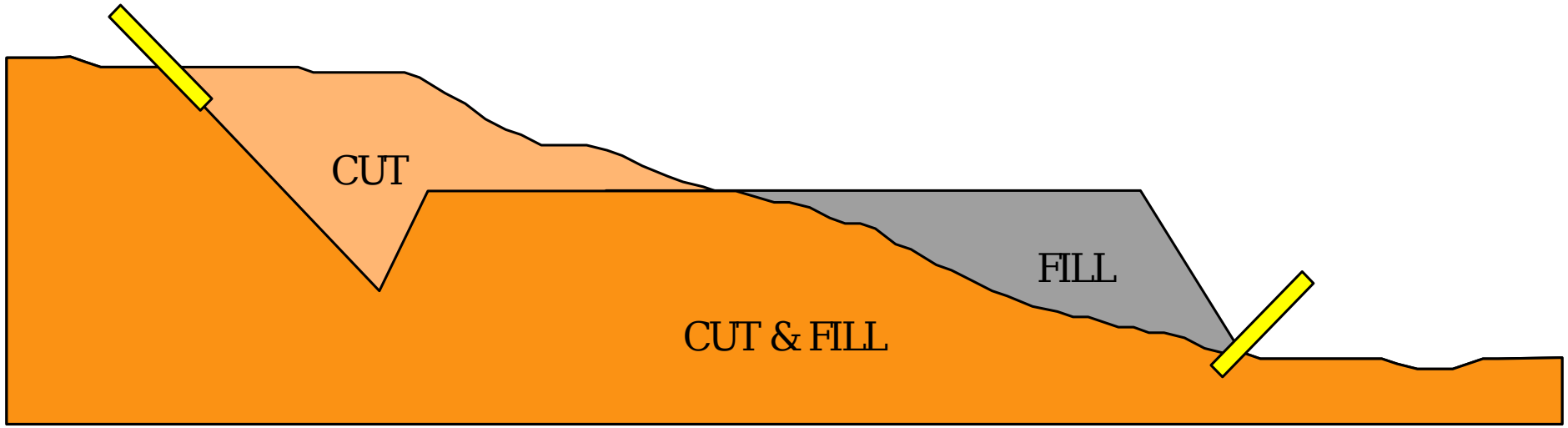
SLOPE STAKES

- **These stakes establish the earth moving limits, left and right of the centerline.**
- **Slope stakes are placed at the left and right limits of the roadway facing the centerline at a 45 degree angle.**
- **They identify the top of cut on the back slope of a ditch, or the toe of fill on an embankment.**
- **They are marked with the slope ratio and station value on the back of the stake, and are marked with the cut or fill value and distance from the centerline on the front of the stake.**

SLOPE STAKES



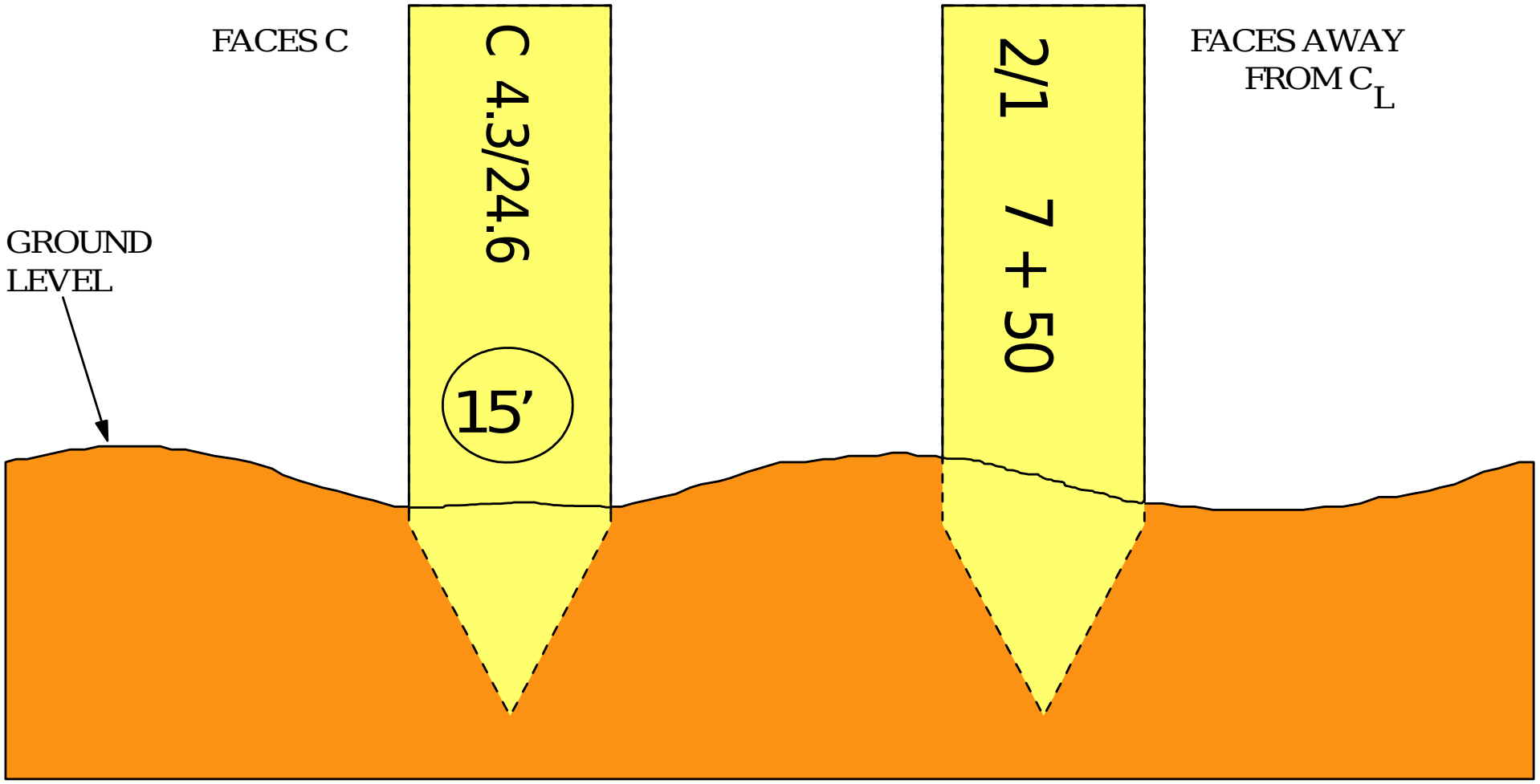
SLOPE STAKE PLACEMENT



OFFSET STAKES

- **Offset stakes are placed as references out beyond the slope stakes at key stations.**
- **They are used as a backup reference for the surveyors to reestablish critical alignment stakes that may have been disturbed during earth moving operations.**
  - **Reference the BOP station.**
  - **Reference the EOP station.**
  - **Reference curve stations and culvert locations.**

OFF SET STAKE



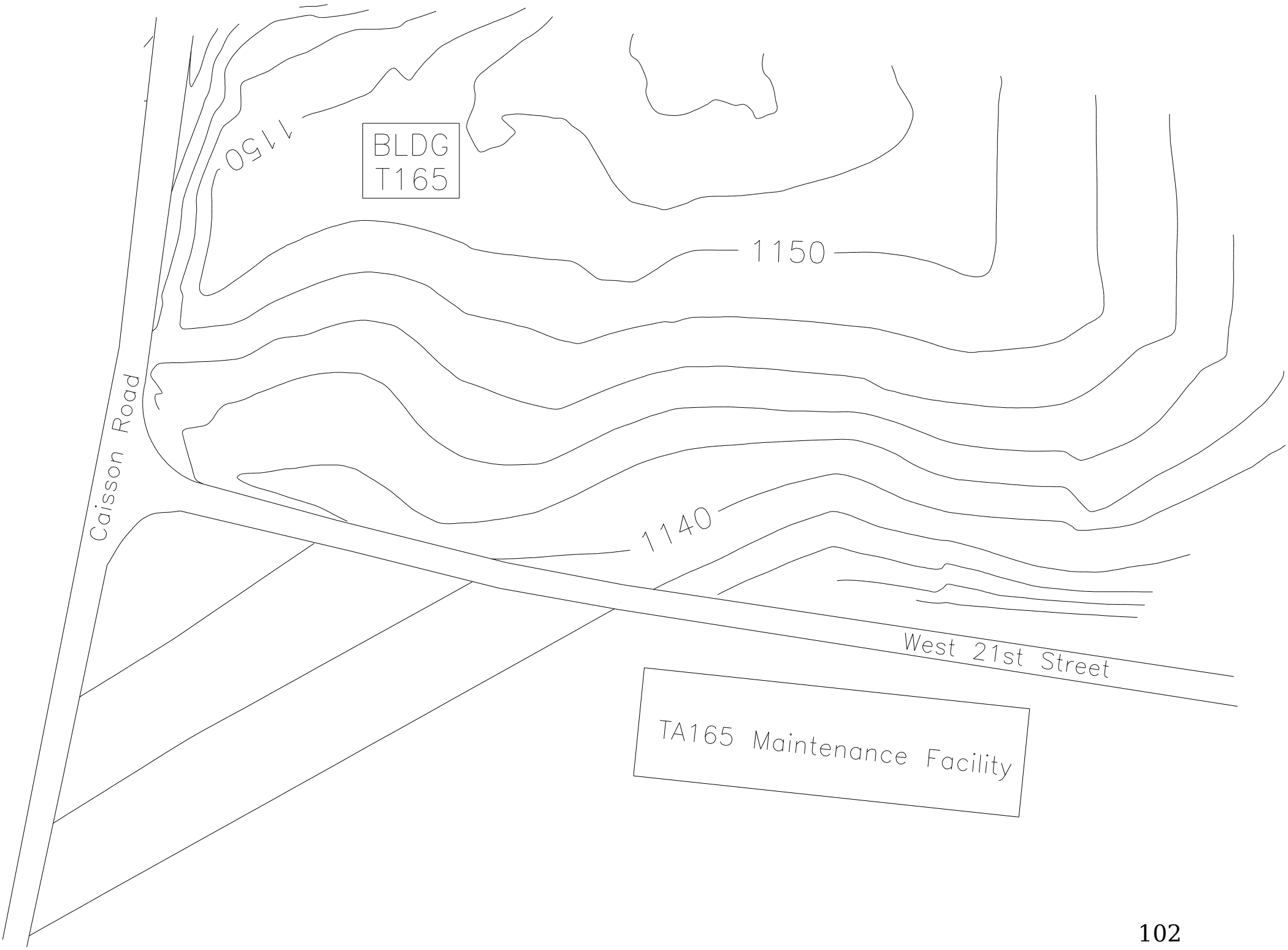
QUESTIONS?

CONSTRUCTION PLANS

- **Finished drawings are used in the development of all military roads.**
- **Construction plans provide layout information to the Engineer Assistants.**
- **These plans are critical to the Engineer Equipment Chief as a tool to supervise construction surveys and earth moving operations.**

SITE PLAN

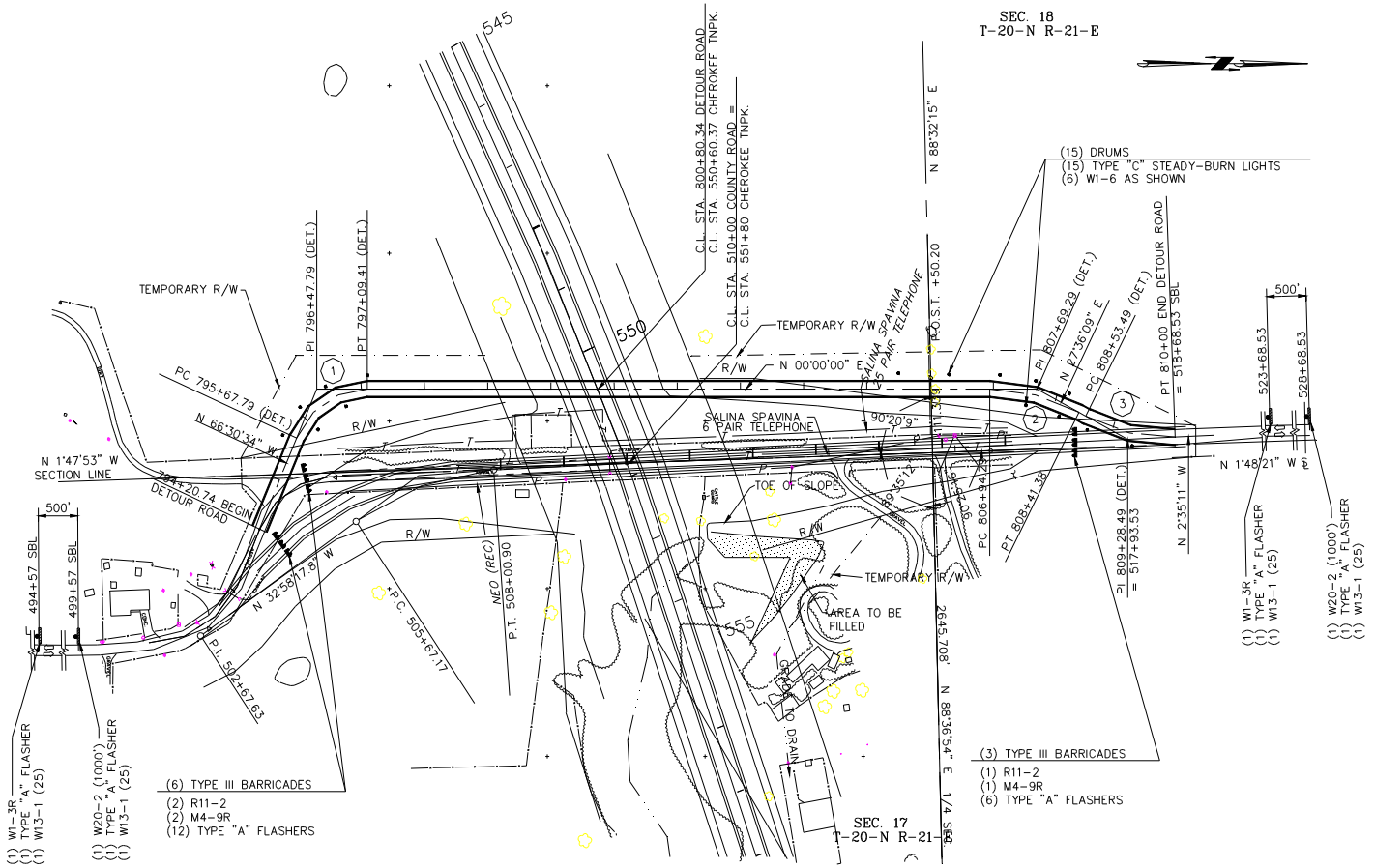
- **A site plan shows all existing manmade and natural features on the existing project site before construction begins.**
- **This drawing is created after the preliminary survey has been conducted.**
- **Terrain relief is shown by contour lines placed at two or five foot contour intervals to clearly show the topographic relief of the intended road route.**


1150
BLDG
T165
1150
Caisson Road
1140
West 21st Street
TA165 Maintenance Facility

PLAN AND PROFILE DRAWING

- The plan view is a "Top View" looking down on the road.
- This is the primary drawing used for the location and layout of the road, showing all horizontal alignment information for staking the centerline of the road, and culvert locations.
- The profile is a sectional view taken along the centerline of the road, and shows the existing ground elevations and proposed grade line elevations.

OKLAHOMA TURNPIKE AUTHORITY				
SECTION ENGINEER	SECTION	CONTRACT NUMBER	SHEET NO.	TOTAL SHEETS



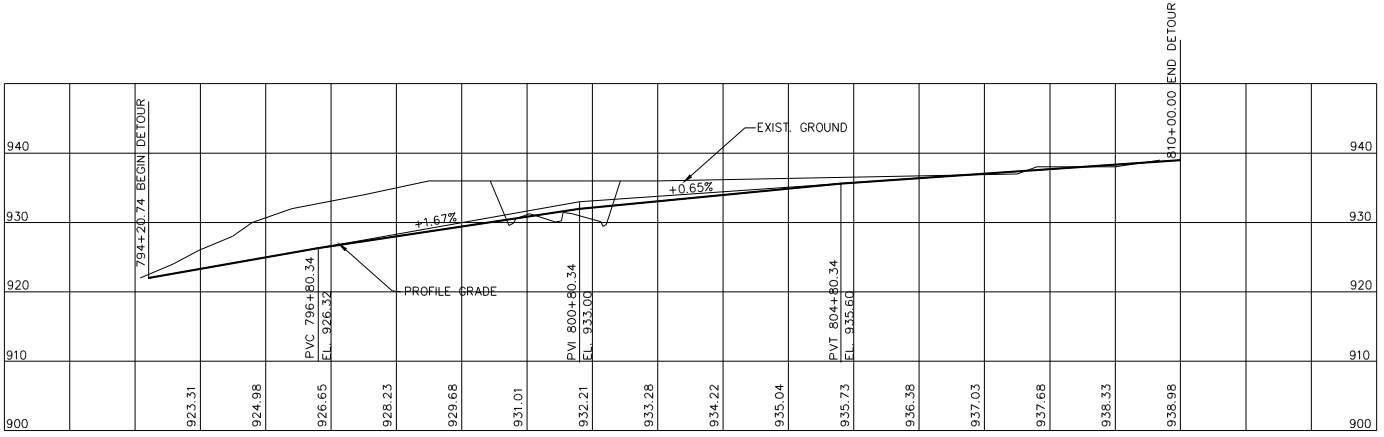
#1 DETOUR CURVE DATA
PI STA. 796+47.81
Δ=66°30'34"
D=46°57'49"
T=80'
L=141.62'
R=122.0'
E=23.89

#2 DETOUR CURVE DATA
PI STA. 807+69.32
Δ=27°36'09"
D=18°46'12"
T=75'
L=147.09'
R=305.25'
E=9.07

#3 DETOUR CURVE DATA
PI STA. 809+28.49
Δ=30°11'20"
D=20°36'17"
T=75'
L=146.51'
R=278.07'
E=9.94

ROUTE	POINT	STATION	COORDINATES NORTH	COORDINATES EAST
℄ BASE LINE	P.I.	502+67.63	452555.90	2855805.56
℄ BASE LINE	P.C.	505+67.16	453207.20	2855642.55
℄ BASE LINE	P.I.	506+86.85	453307.61	2855577.41
℄ BASE LINE	P.T.	508+00.90	453427.17	2855572.01
℄ BASE LINE	P.T.	510+00.00	453626.07	2855563.02
℄ BASE LINE	P.T.	516+50.00	454275.41	2855533.69
℄ BASE LINE	P.O.T.	519+00.00	454264.13	2855783.44
DETOUR @ STA 551+80				
℄ DETOUR	P.O.T.	794+20.74	453044.48	2855659.62
℄ DETOUR	P.C.	795+67.79	453103.09	2855524.75
℄ DETOUR	P.I	796+47.79	453134.98	2855451.38
℄ DETOUR	P.T.	797+09.41	453214.98	2855451.38
℄ DETOUR	P.C.	806+94.29	454199.87	2855451.38
℄ DETOUR	P.I.	807+69.29	454274.87	2855451.38
℄ DETOUR	P.T.	808+41.38	454341.30	2855486.12
℄ DETOUR	P.C.	808+53.49	454352.03	2855491.73
℄ DETOUR	P.I.	809+28.49	454418.50	2855526.48
℄ DETOUR	P.C.	810+00.00	454493.42	2855523.09

SHOO-FLY & CONSTRUCTION SIGNING AT CROSS STREET – STA. 551+80
SPECIAL DETOUR



NO.	REVISION	BY	DATE

OKLAHOMA TURNPIKE AUTHORITY
CHEROKEE TURNPIKE

PLAN SCALE 1" = 100'

PROFILE SCALE HORIZONTAL 1" = 100' VERTICAL 1" = 10'

SPECIAL DETOUR SHT. #3

THE BREISCH COMPANY INC.
ENGINEERS ARCHITECTS PLANNERS
SAND SPRINGS, OKLAHOMA 74063

SECTION

DESIGNED	LWB
DRAWN	WAR
CHECKED	LWB

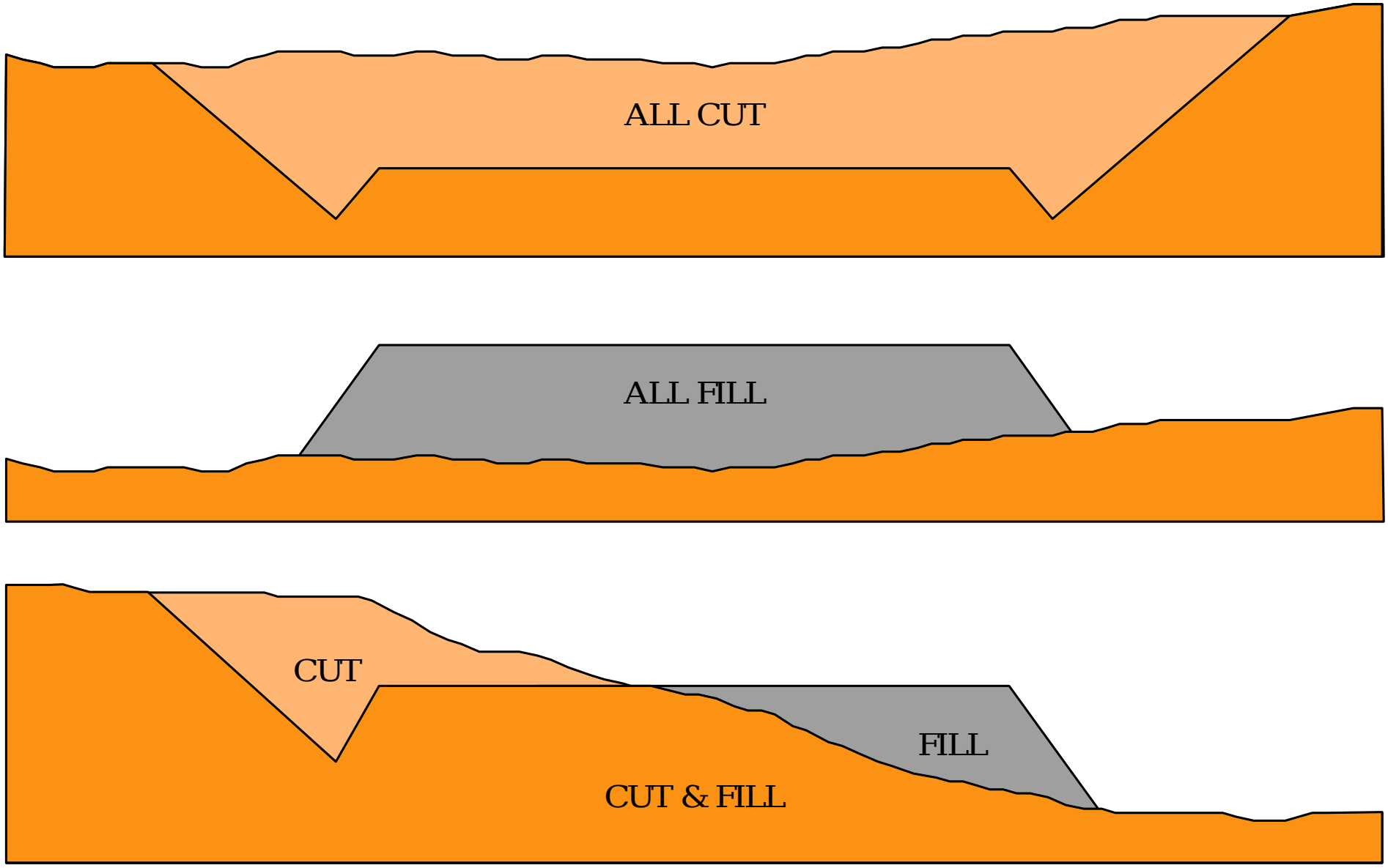
CONTRACT NO.

DATE AUG. 11, 1989 SHEET OF

CROSS SECTION DRAWING

- **The cross section is a section view of the road, cut perpendicular to the centerline, looking in the direction of travel. There are two types of cross section drawings:**
  - **Earthwork Cross Sections: These drawings show the existing ground line and proposed road grade line. This is the primary drawings that are used to generate earthwork volume estimations.**
  - **Typical Cross Section: This drawing will show the road dimensions, slope ratios, and types of materials to be used to construct the proposed road.**

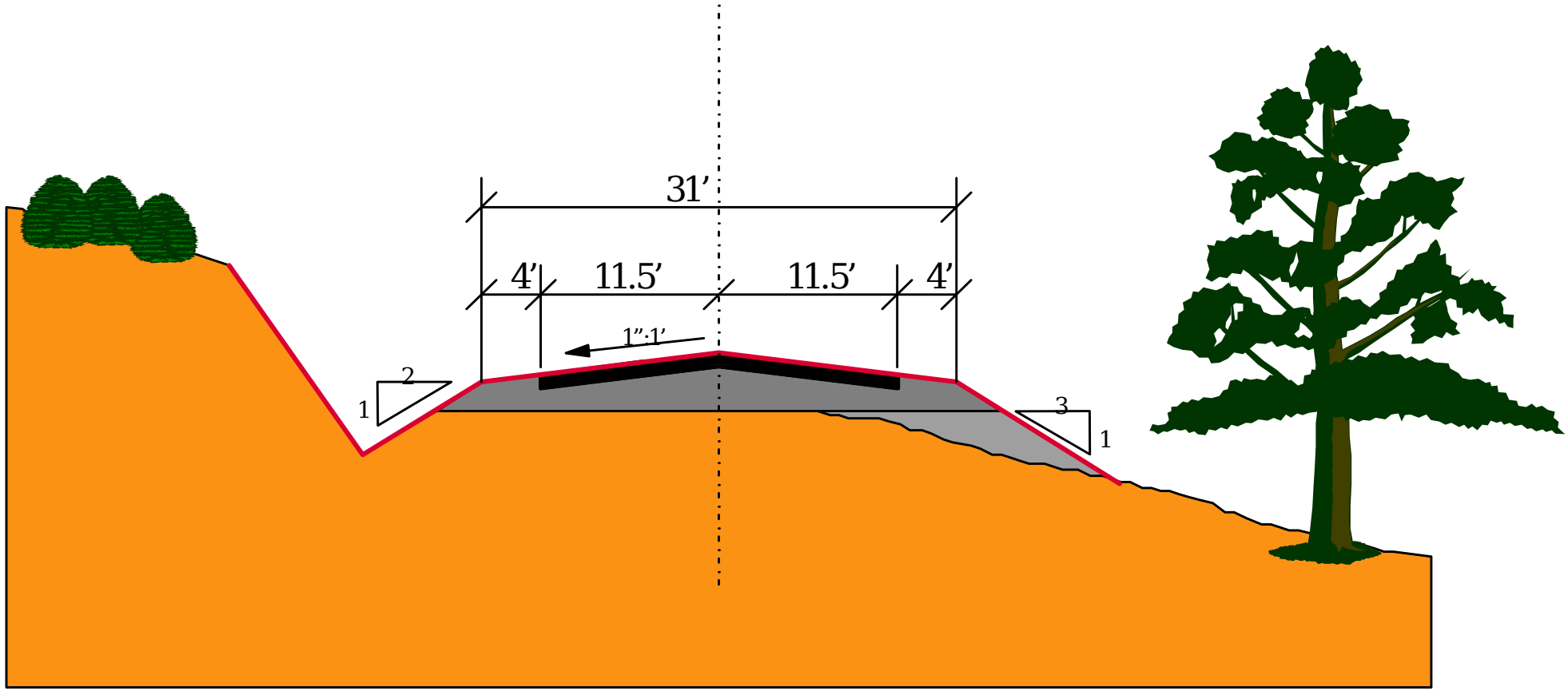
EARTHWORK SECTIONS



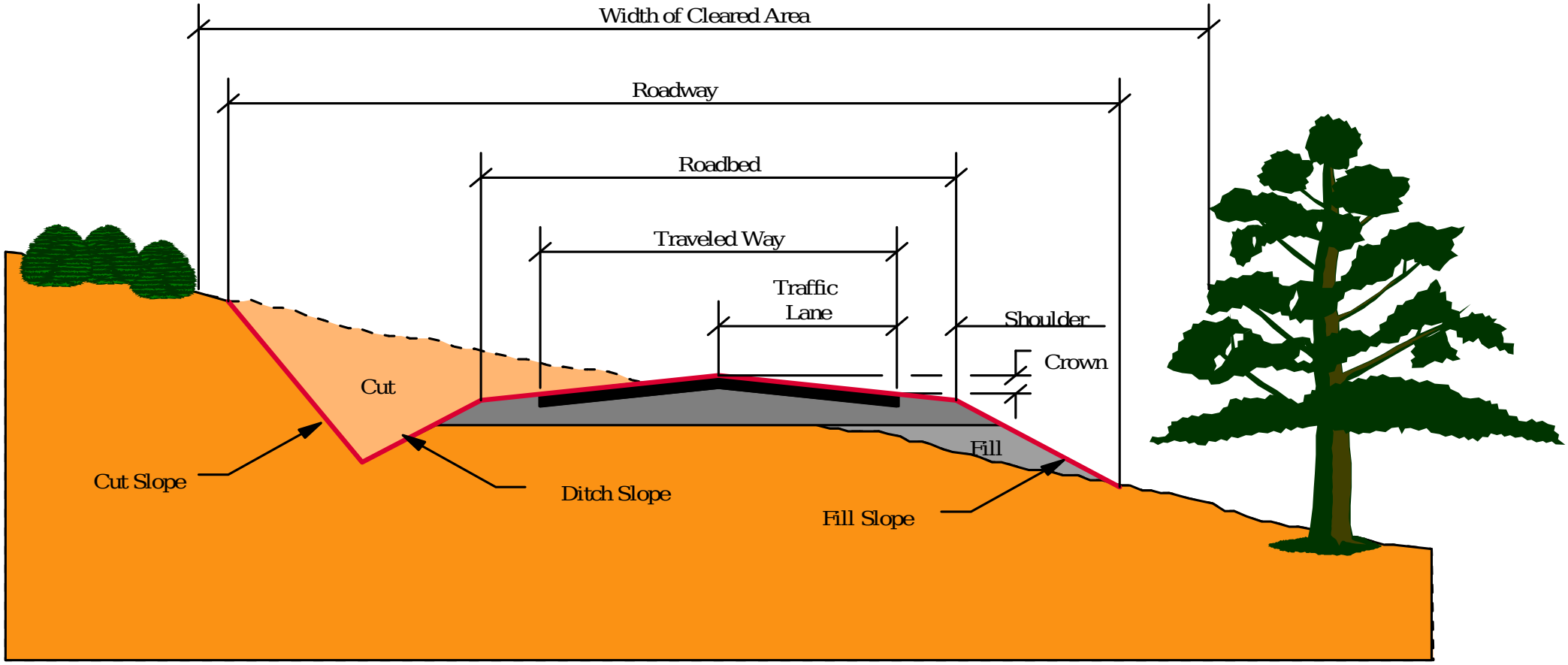
TYPICAL CROSS SECTION FEATURES

- WIDTH OF CLEARING
- ROADWAY
- ROADBED
- TRAVELED WAY
- TRAFFIC LANE
- ROAD CROWN
- ROAD SHOULDERS
- DITCH SLOPE (Front Slope)
- CUT SLOPE (Back Slope)
- FILL SLOPE

TYPICAL SECTION
FOR MILITARY ROADS



ROAD COMPONENTS
TYPICAL



PLANS AND SPECIFICATIONS

- **As mentioned previously, construction plans are tools used in supervising the construction of a military road. These plans, along with specifications, must be provided to the Engineer Equipment Chief.**
  - **Site Plan.**
  - **Plan and Profile Drawing.**
  - **Cross Section Drawings.**
  - **Earthwork Volume Estimations.**
  - **Layout Specifications.**

QUESTIONS?

ROAD CLASSIFICATION:

- Select the type of road that is required with the structural requirements that can accommodate traffic volumes throughout the life of the road.
- Road types are selected based on their classification.
- For the types of roads we are generally tasked with constructing or rehabing, the classes of roads we deal with are class C or class D.

DEMONSTRATION

Road Classification

- Initially, you must know the estimated vehicle usage numbers to calculate the average daily traffic (ADT) and the design hourly volume (DHV) for the intended road.
- Average Daily Traffic (ADT): Estimated number of vehicles x 2 (round trip).
- Design Hourly Volume (DHV): ADT 4 24 (hours in one day)
- Design Hourly Volume (DHV): ADT

Road Classification

The ADT and DHV values are compared to the established road geometric design criteria to determine what classification of road is to be constructed. The design criteria for the class of road that has been selected must be equal to or greater than the calculated ADT or DHV for a given road class.

Once the road classification has been determined, your design parameters must fall within the established standards. The

ADT & DHV FORMULAS:

Example: A road is to be constructed for an estimated 75 vehicles.

Step #1: Compute Average Daily Traffic (ADT).

- **ADT = No# of vehicles x 2 (round trip)**
  - **75 x 2 = 150 vehicles per day.**

Step #2: Compute Design Hourly Volume (DHV).

- **DHV = No# vehicles per day / 24 (hours in 1 day).**
  - **150 / 24 = 6.25 vehicles per hour.**
- **#DHV = No# vehicles per day x 0.15 (rush hour constant).**
- **150 x 0.15 = 22.5 vehicles per hour.**

- **Step #3: Compare computed values to design controls to determine which class of road is required.**

QUESTIONS?

PRACTICAL EXERCISES

QUESTIONS?

HORIZONTAL CURVE DESIGN PRINCIPLES

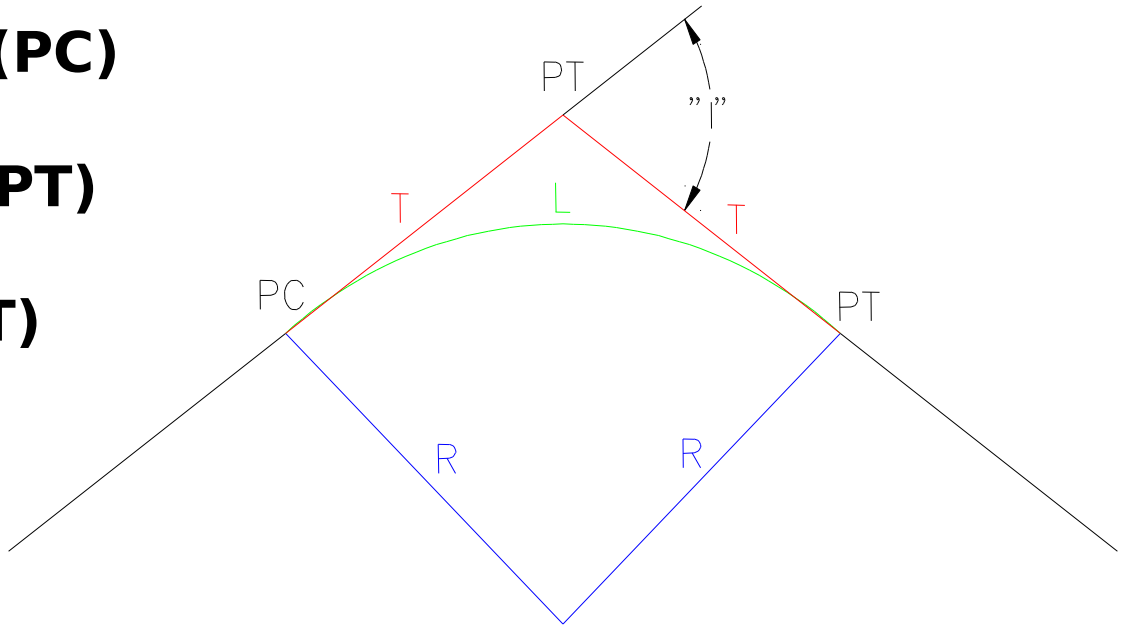
- Straight sections of road (Tangents) should be as long as possible.
- Limit the number of horizontal curves.
- Design curves as long and smooth as possible to increase vehicle capacity on the roadway.
- Gentle curves increase the curve length, and lengthen the curve tangents.
- Always follow road classification specifications for curves.

TYPES OF HORIZONTAL CURVES

- **Simple Curve**: Simplest curve to design and construct for low speed road design.
- **Compound Curve**: Two simple curves connected at a common point turning in the same direction, but with different radii.
- **Spiral Curve**: Series of simple curves connected at different common points. Normally found on interstate systems as on and off ramps.
- **Reverse Curve**: Two simple curves joined together at a common point, turning in opposite directs. Normally used in railroad construction.

HORIZONTAL CURVE ELEMENTS

- **Point of Intersection (PI)**
- **Point of Curvature (PC)**
- **Point of Tangency (PT)**
- **Tangent Distance (T)**
- **Radius (R)**
- **Length of Curve (L)**
- **Intersecting Angle (I)**



CURVE DEFINITIONS

- The degree of curvature (D) is used to determine the sharpness of the curve. The larger the degree of curvature is, the sharper the curve will be. The degree of curvature is expressed by one of two definitions:
  - **Arc Definition**: The degree of curvature is the angle which subtends a 100 foot arc along the curve. Used primarily in military road design.
  - **Chord Definition**: The degree of curvature is the angle which subtends a 100 foot chord on the curve. Used primarily in railroad design.

Alignment Design

There are several methods available for creating alignments. You may go straight to your software and create it by manually inputting coordinates, angles and distances, or simply create the alignment in Terramodel by drawing it as a polyline.

QUESTIONS?

VERTICAL ALIGNMENT DESIGN

- The particular road classification establishes the maximum allowable grades that can be used to design the grades for a road.
- Earthwork operations are the largest single work item performed during road construction.
- Balancing cut and fill volumes is generally done by simple observation following these guidelines:
  - Match design grade line elevations with existing ground elevations at the BOP and EOP.
  - Ensure proposed grade lines for the tangents fall below the grade limits allowed for the road classification.

TYPES OF VERTICAL CURVES

- After grade lines have been designed, vertical curves must be designed at the location of points of vertical intersect.
- Vertical curves allow for a smooth transition from one tangent grade to the next, vertically.
- There are two basic types of vertical curves, both of which are designed the same way using different specifications to dictate their dimensions:
  - **Overt (summit) Curves**
  - **Invert (sag) Curves**

VERTICAL CURVE ELEMENTS

- **Point of Vertical Intersection (PVI)**
- **Point of Vertical Curvature (PVC)**
- **Point of Vertical Tangency (PVT)**
- **Percent of Grade (G1 and G2)**
- **Offset's (O)**
- **High Point (HP)**
- **Low Point (LP)**

QUESTIONS?

SOIL STABILIZATION

- **Soil stabilization is the process to alter, or preserve one or more properties of a soil to improve its engineering characteristics and performance.**

STABILIZATION FUNCTIONS

Selection of a soil stabilization process, or material, depends on the reason why stabilization is needed.

- **Stabilization serves three specific functions:**
  - **Strength Improvement: Increases the strength of the soil.**
  - **Dust Control: Eliminates or reduces dust that is generated.**
  - **Waterproofing: Preserves the constructed strength by preventing the entry of surface water.**

STABILIZATION METHODS (Mechanical)

- **The most widely used method, mechanical stabilization, involves blending soil materials, followed by compacting. This is the most efficient type of stabilization.**
  - **Blending involves mixing one soil type with another to improve the engineering characteristics of the original soil.**
  - **Compacting a soil is the oldest, and most important means to increase the strength of a soil.**

STABILIZATION METHODS (Chemical)

- **This process involves adding granular material or chemical admixtures to the soil.**
- **Stabilization using a soil and lime, Portland cement mix is more costly, but more economical in the long run.**

SUBGRADES

- **The subgrade is the foundation of the road itself.**
- **It must be stable and compacted well to support any loads.**
- **If not properly constructed, the road will fail.**

COMPACTING SUBGRADES

- **Compaction increases the strength of the subgrade soil.**
- **Compaction is simple in fill areas, because the layers are constantly being compacted during construction.**
- **Compaction in cut sections require more attention so the subgrade will resist further compression under vehicular traffic.**

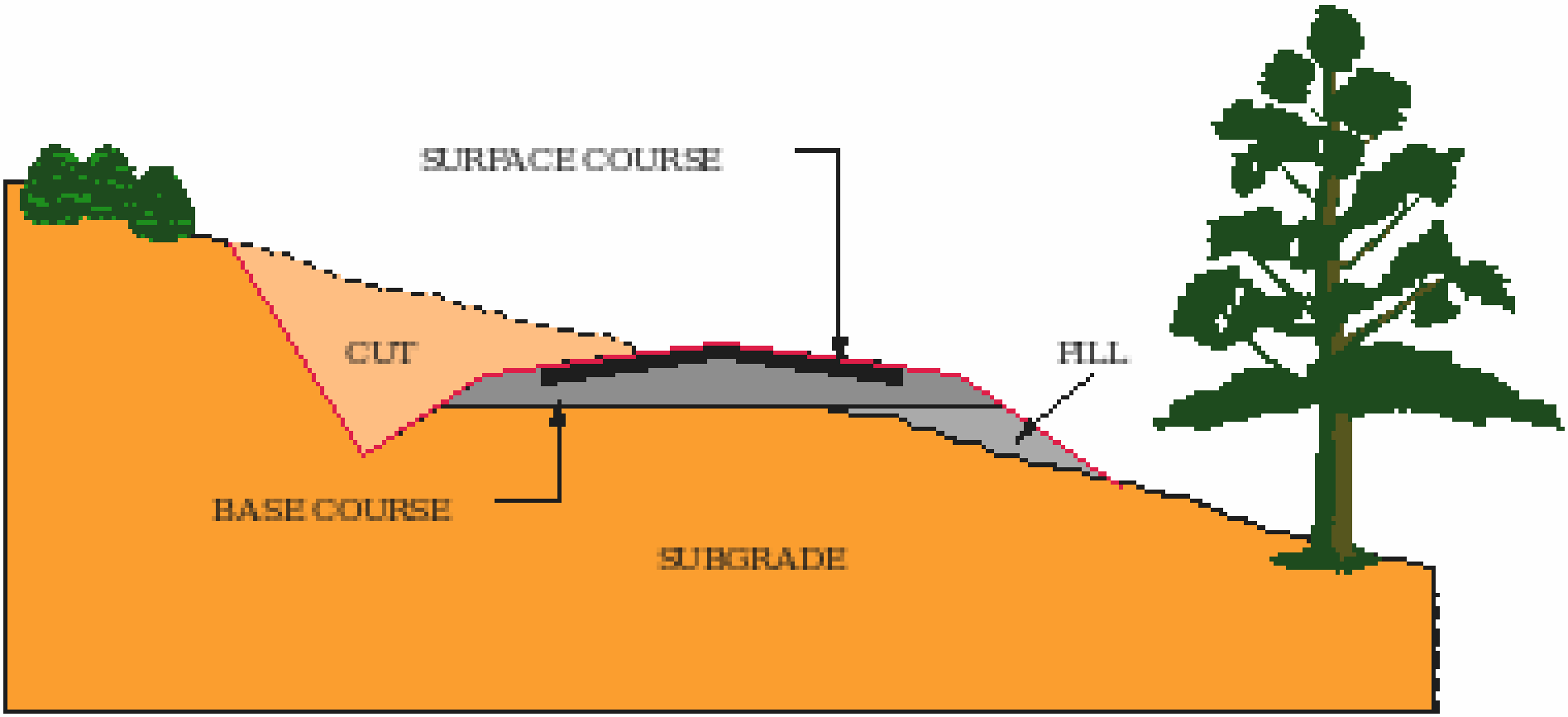
BASE COURSES

- **The purpose of the base course is to establish a wearing surface that will distribute the stresses of the wheel load to the subgrade.**

BASE COURSE MATERIALS

- **Materials such as limestone , crushed coral, shell, and crushed granite provide a strong surface for base courses.**
- **The lift thickness must be compacted to attain the required density to distribute the load.**
- **Material particles used in the construction of the base course should be less than or equal to 1/2 the compacted lift thickness.**

ROAD COURSES



QUESTIONS?

SUMMARY